Predicting Future Basel 5: Potential Evolution of Internal Models and Regulatory Environment

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Agenda

Although Basel 4 is not live yet, can we predict "Basel 5"? Yes, in some areas

- Past evolution of regulatory modelling requirements for internal models
  - History; multimode implications; the rise and fall of User Test
  - Credit to Liquidity conversion and role of Initial Margining (IM)
- New challenges to CCR IMM models
  - Impact of IM on IMM CCR
    - Modelling IM
    - Payment risk
    - Impact of Initial Margin on risk factor modelling: modelling extreme scenarios
  - Capturing extreme scenarios/events
    - Single asset class
    - Long term evolution: extreme events vs. extreme scenarios
    - Cross-asset
- Did we see this before? Lessons from IMA evolution in market risk Basel 2.5 to Basel 4
- New challenges to market risk IMA models: machine learning and regulatory evolution
- Summary: what to expect in 2027 or potential elements of "Basel 5"
- References; Acknowledgments; Appendix: Modelling IM

Risk regulations and models (I): from no connection

- Basel I (published 1988)
  - “to secure international convergence of … the capital adequacy of international banks”
  - A very basic definition of Risk Weighted Assets (weight was function of the asset category)
  - Only credit risk was included in the framework
  - Rules for taking into account diversification practically non existent; [Market and Operational risk introduced later: 1996 and 2006]
- Best risk practices in quantitative risk and regulatory requirements are not usually connected – risk is treated under “<u>Dual Mode</u>”
  - Change starts with CAD II: VAR.
- CAD II - Capital Adequacy Directive (published 1996):
  - Possibility to calculate capital requirements based on bank’s internal model, portfolio based - VAR

Risk regulations and models (II) : … to aligned

- Basel II (2006)
  - Takes account of portfolio risk framework – Economic Capital style model as ultimate driver
  - Takes into account changes in banking and risk management
  - Revision of the standard framework; the granularity of the risk weights is increased; operational risk capital charge is introduced

- Best risk practice in quantitative risk area and regulatory requirements are further aligned: possibility of calculating the capital requirements via internal model also for counterparty risk
  - Two pillars of quantitative risk modelling of investment banking: VAR and PFE (EPE) are aligned
  - Dual mode is allowed*, but discouraged

The IRB Use Test: Background and Implementation", Newsletter No. 9, BCBS, September 2006

Risk regulations and models (III) : to prescribed…

- Basel 2.5 (live* 2012): more capital on market risk
  - IRC: "internal" model with prescribed risks; CRM: "internal" model and a standard floor
    - Up to 1 year horizons (liquidity horizon: 3 months to 1 year)
  - Stressed VAR: "internal" choice of period & proxies
- Basel 3 (live* 2014)
  - More regulation on liquidity, more capital
  - Prescriptive amendments to EPE (PFE): stressed EPE; VAR on "CVA"; stressed VAR on "CVA"; "internal" choice of period; modelling approach is a hybrid between internal and prescribed (WWR, treatment, reg. CVA)
  - Is Dual/[multi] Mode coming back? (and who pays for it?)
- [Basel 4:]
- Fundamental Review of the Trading Book ~ 2019-2021*…
  - Expected Shortfall; long(er) horizons; more aggressive hybrid between internal and prescribed modelling
  - Prominent role for Standard Approach
- SA CCR, changes to CVA, Operational Risk, potential introduction of various floors ~ 2019-2021…

**in EU*

Risk regulations and models

- The recognition of models (or at least the need for models) is preserved, but the best risk practice and regulatory requirements/incentives are not well aligned
  - “Multi-mode” IMM may not be affordable financially and politically
- What does it mean for our profession and our plans? Are regulators killing or strengthening the profession of quantitative risk?
  - Is affordability of “multi-mode” the only problem? – It will take us more then this presentation to have a detailed discussion, but let’s take a wider look:
- Evolution of “Risk Conversion” paradigm
  - We started with collateral (CSA) introducing “VM” – Credit to Liquidity conversion
  - Then moved to Credit to Market conversion – hedging of (C)xVA
  - And now again Credit to Liquidity conversion via *IM margining* (CCP, EMIR…)
  - Is it always better? Are we equipped to model [il]liquidity risk?
- Evolution of markets (emergence of regular dislocations), *extreme scenarios*
- Potential blending of functions:
  - Risk vs. Capital vs. Funding costs (FVA/MVA) vs. ALM
  - Are we equipped to act across department lines or merge them?
- (Longer term question: what risks should stay within the banks?)

Risk regulations and models

This gives following potential Basel 5 topics:

- "Multi-mode" IMM
  - If regulators do not like "unwarranted model variability", what would they think about variability of multi-mode use?
    - Internal risk use angle
    - Cross model dependency
    - Pillar 2 angle

So far we can predict topics (a title of a section?) in a future Basel 5, but not what it will state. How about other topics?

Next group of topics are interlinked:

- Extreme scenarios
- IM margining consequences
- [Il]liquidity risk

The above has common thread of margining and for some impacts we may have a blue-print for the future regulation, if we consider past evolution of regulatory requirements for market risk

- So we look at IM itself and CCR residual risk after IM introduction

Introduction of IM: impact on IMM CCR

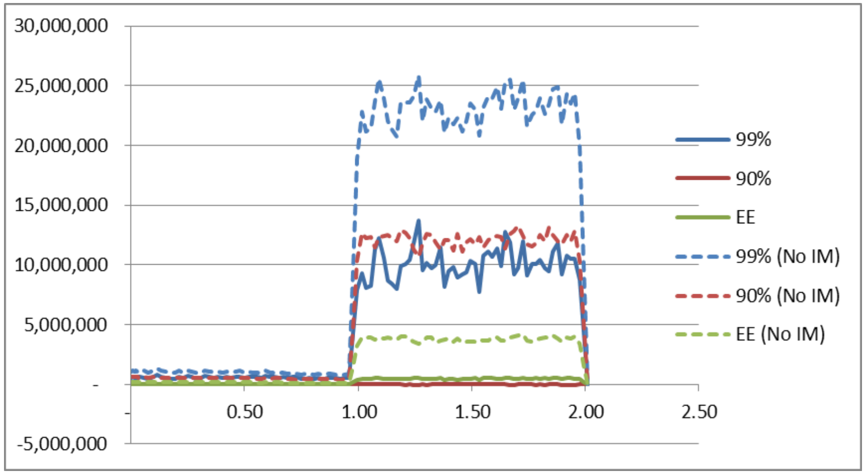
- We return to narrow question of model evolution
- **Introduction of Initial Margin is key influence on IMM CCR evolution in the medium future**
- Initial Margin (IM) is collateral taken to cover the exposure arising from the Margin Period Of Risk, i.e. a short horizon "VaR"[1]
- Now we have increasing use of VaR based margin:
  - CCPs mostly use VaR-based margin and we pass on these margin requirements to clients for cleared derivatives
  - "Bilateral Margining" for non-cleared OTC became a requirement, whereby both parties post IM to a third-party. The industry started to use of a standardised VaR Model (SIMM) to calculate these IM requirements
- IM very significantly offsets exposure on client trades but possibly increases exposure on CCPs[2]. We focus here on the client and bilateral exposures, i.e. where the IM reduces exposure
  - Example portfolio – 2 vanilla calls 1Y (short) and 2Y (long) maturity; IM calculated with dynamic model. (For IM modelling discussion also see [1])

[1] With some subtleties – the VaR, coming purely from moves in the underlying market factors, is one component of the MPOR exposure; there are also cashflow effects and wrong-way risk effects, which are conventionally not included or restricted in IM calculation.

[2] Whether or not we are at direct risk of losing the IM posted to a CCP depends on its set up. We would not usually be at risk for the IM posted to a third-party unless it also defaults.

Introduction of IM: impact on IMM CCR

- Example portfolio – 2 vanilla calls 1Y (short) and 2Y (long) maturity



- IM has three main sequences on IMM CCR model:
  1. **We need to model IM and understand approximations involved**
- Introduction of IM removes significant part of CCR (Credit to Liquidity risk conversion). The residual risk becomes more prominent:
  2. **Payment risk ("spikes")**
  3. **Remaining exposure is based largely on extreme scenarios**

Capturing IM in CCR

- Static IM attached to trades is easy to model in counterparty exposures. Much harder though to simulate the future evolution of variable IM
- For Risk challenge is to represent the future evolution of IM conservatively, i.e. biased toward under-estimation of the future IM. Good model should cover extreme scenarios. (xVA/pricing requires accurate expectations)
- Broadly there are four possibilities:
  - Flat IM – we keep the IM constant through time. This can be considered as a base assumption but potentially: conservative at the short, aggressive at long end
  - Static trade allocation – we split the portfolio IM known at day zero amongst the trades but then keep them static through time, except that as trades mature in simulation time, their IM portion disappears
  - Dynamic – we use the "VaR" calculated within the CCR model at each forward time (i.e. from our MPOR exposure calculation) as a proxy for the IM* – we get a profile of IM
  - Stochastic – we estimate the VaR within the CCR model at each forward time per scenario – we have a distribution of IM
  - For detailed examples see Appendix and References slides
  - Also: a topics of WWR/pro-cyclicality, e.g. IM CCP and SIMM could strongly differ in this area: how sensitive to market stress/major c/p default, ability to recalibrate.

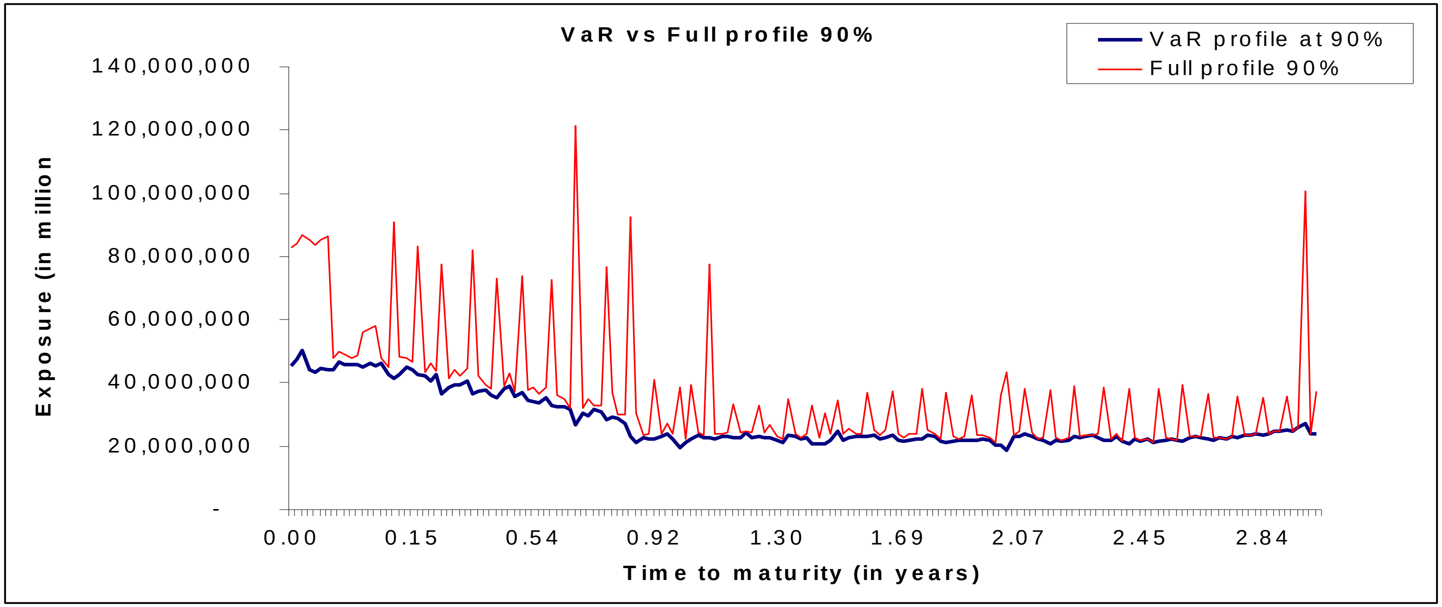
* Potentially with some scaling / basis

Modelling residual risk. Payment Risk (“spikes”)

- Recall: Introduction of IM removes significant part of CCR (Credit to Liquidity risk conversion). The residual risk becomes more prominent:
  2. **Payment risk (“spikes”)**
  3. Remaining exposure is based largely on extreme scenarios
- Payment risk is a close relation of familiar settlement risk, however it reflects pre-settlement dynamics and collateral agreements
- Two level of modelling
  - Basic – trade’s payment vs. collateral payment
  - Advanced – payments variability during MPOR (conditionality on default)
- Basic: MTM < 0, we post collateral, (abs(*MTM*) = *c* under gold standard CSA). Trade “re-sets”: regular payments; re-setting of equity swap; settlement at the end of the trade. In default, for equity swap we pay full MTM, but collateral is not returned. This produces payment “spike”
- Advanced: MPOR is separated into “control” and “no control” period
  - Defaulted counterparties do not pay during grace period
    - No cashflows in, but initially we still pay out (“no control” period)
  - We do not pay once default is recognised
    - Nothing in, nothing out (“control” period)

Payment Risk ("spikes")

- Collateral – actual cashflows are conditional on default
  - No cashflows in, but we pay ("no control" period)
  - Nothing in, nothing out ("control" period)
- Conditionality on default makes backtesting difficult. Realised valued from portfolio observations (no default):
  - All in, all out
  - In fact, backtesting of residual risk is a general problem
- Full risk profile = VaR profile + Payment (Cashflow) Risk



Modelling residual risk: extreme scenarios

- Exposure (VAR-profile) not covered by IM is based largely on some extreme scenarios **which are unlikely to be very well modelled…** – are we stretching the IMM/PFE/EEPE concept too far?
- What to do?
- Modelling extreme events for risk factors is needed to capture post-IM exposure reliably
  - Extreme exposure scenarios may not be linked to extreme scenarios of underlying market risk factors, but often are
  - Counterparty portfolios are often directional
  - Existing exposure hedges may not target extreme events

Modelling extreme events

- Modelling extreme events come with three main challenges

- **Challenge 1.** Extreme events in a **single asset class**
  - What problems do we face?
- Example. Industry standard – GBM (simple Black-Scholes) is a common IMM CCR model for equity asset class and does not cover extreme events
- What needs to be added? Two broad sources of extreme events:
  - Firm's economics – catastrophic deterioration (i.e., rapid and not anticipated by markets) of firm's health
    - This can be reflected via rapid (jump-like) rating migration and/or default.
  - Capital markets – rapid change in market sentiment; could be name specific and market wide
    - Adding jumps to a diffusion process is a common modelling approach
- Additional modelling considerations. The modelling of extreme events should be compatible with WWR/conditionality of default; multi-mode use (regulator, internal risk/limits, xVA), <u>stress testing framework</u>

Modelling extreme events

- **Challenge 2.** Extreme ***events*** assume ***fas***t risk factor change (within MPOR time scale), however ***long term extreme scenarios can also have an impact***
  - Example. Charge of main risk drivers: path to default may be a slow process (not catastrophic), but once nearing or in default recovery becomes major driving risk factor, not secondary
  - Other low probability long term scenarios with potentially different risk regimes:
    - Hyper inflation
    - De-pegging
    - Peak oil/all-renewables
- Again, additional modelling considerations. The modelling of extreme scenarios ideally should be compatible with
  - WWR/conditionality of default
  - multi-mode use (regulator, internal risk/limits, xVA)
  - <u>stress testing framework</u>

Modelling extreme events

- **Challenge 3.** Building a model for single asset class is only a part of the required solution. ***Extreme events tend to propagate across asset classes***
  - Example. Equity-credit link, see [2] for details. If a name defaults, equity goes to (near) zero, credit is driven by recovery values
- Extreme events are best modelled in cross-asset framework, but modelling joint extreme events has a particularly large model uncertainty
- Most banks have pre-existing IMM models and development will be incremental
- Ability to model extreme events across asset classes may influence existing single asset models
  - <u>*Cross-asset*</u> links may change the <u>*intra-asset*</u> dependence
  - Example. Introduction of a jump-to-default mechanism into the equity processes (assuming one is already present and therefore copied from IMM CCR credit spread model), will change the dependence between any two equities – long term evolution will be affected by their default correlation

Modelling extreme events: Did we see this before?

- Have we seen similar challenges before? and what did we learn?
- Yes, in market risk
  - Single asset class: IRC and CRM operating at 99.9% aiming to capture extreme events (migration and default) [3]
  - Cross-asset: DRC covers default in equity and credit [4], (Stressed) ES is a cross-asset mean-over-threshold measure with similarities to EE under IM
- Advanced model for extreme scenarios/rare events can
  - Make potential catastrophic events visible within common modelling framework
  - Complement direct stress tests, enable model-based reverse stress tests
- But also
  - Has high model uncertainty and high calibration uncertainty
  - Model review and validation are challenging
  - <u>Back testing is restricted at best</u>
- What was regulatory response in market risk?

Modelling extreme events: regulatory view

- What was regulatory reaction in market risk ?
    - Single asset class: IRC and CRM operating at 99.9% aiming to capture extreme events (migration and default) [3]
    - Cross-asset: DRC covers default in equity and credit [4], (Stressed) ES is a cross-asset mean-over-threshold measure with similarities to EE under IM
- Advanced model for extreme scenarios/rare events required, but also
- Backtesting requirement relaxed
    - IRC/DRC and SES are not back tested
    - ES is back tested (primarily – recall *p* values) at 97.5% and 99%, not above.
- Regulators oppose “unwarranted model variability”
- What will be regulator’s stance for CRR? If they follow market risk IMA approach for potential “Basel 5” then our predictions are:
    - Some extreme events treatment may be prescribed
    - Back testing limitations may be recognised
- Notes of caution
    - A different mood on extreme events modelling in operational risk
    - Role of Pillar 2 for model generation extreme scenarios? (EC, ICAAP…)
- Industry standards may also affect Basel 5. Internal strategy: should bank invest in such models and for which mode (capital, PFE/limits, xVA)?

New challenges to Market Risk IMA: Machine Learning

- If market risk regulatory evolution leads CCR evolution what are the current market risk challenges?
- Machine learning (ML) is making headlines. ML field is wide and has number of potential applications in Risk.
- However to anticipate possible regulatory views let us take a case study: can we build a better VAR/ES tool and what would be regulatory reaction?

- Important practical limitation for Risk departments:
- Banks are unlikely to have either the will or the budgets to develop and maintain two completely different models, even if user test completely abandoned: one ML-based for internal day-to-day risk management and another ‘classical’ for regulatory calculations
  - We look at regulatory challenges of ML VAR/ES acceptance
    - ML VAR as a challenger model – first use in validation?

New challenges to Market Risk IMA: Machine Learning

We look at regulatory challenges of ML VAR/ES acceptance*

- Current regulatory policy expects:
  1. Model transparency and clarity in approximations and assumptions employed by a model
  2. Stability of approximations, i.e. model reliability
  3. Avoidance of pro-cyclicality

- **Model transparency and clarity in approximations and assumptions employed by a model**
  - Obvious: transparent for an expert (developer, user, regulator)
  - May be more important for adoption: cultural acceptance
    - Historic VAR: ‘everything is in the data’ or ‘black box’? Regulators are comfortable or even prefer HVAR - ‘everything is in the data’, but ML VAR is a ‘black box’?

**This ML discussion and references are available in Appendix of [5]*

New challenges to Market Risk IMA: Machine Learning

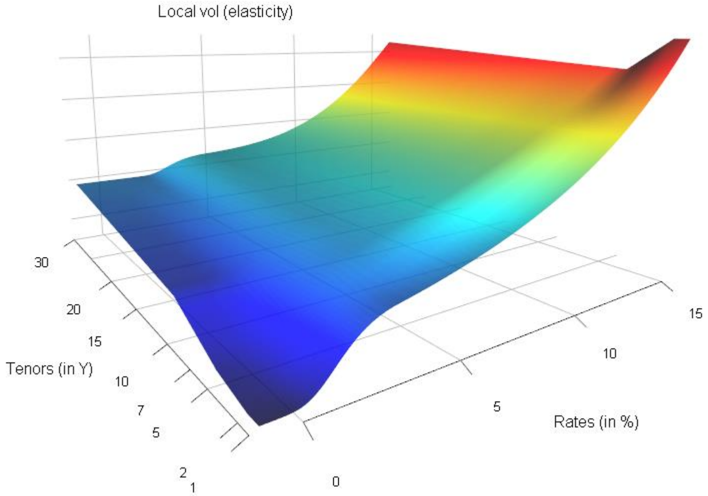
- **Stability of approximations, i.e. model reliability**
  - Dependence (scaling) between short and long time horizon
    - ML derived?
    - Proof of scaling stability to satisfy regulators: may be harder for ML regime than in classical methods
  - Regime stability: whether the model can adequately react and adapt to a regime shift
  - Expand time series into past:
    - Capture previous regime shifts and attempt to uncover long-term universal relationships between data, such as in (Deguillaume, et al., 2013)
    - Impose structural limitation (again as the type of rate returns resulting from (Deguillaume, et al., 2013). [More in the next slides]
  - Restrict the data to a recent period: model to recalibrate itself to regime change ‘automatically’
    - Old debate: structural vs. data driven approaches
    - The problem of pro-cyclicality
  - Link to stress testing framework: potential lack of obvious macro variables may require more advanced stress testing framework to compensate.
- This lead to third point: avoidance of pro-cyclicality

New challenges to Market Risk IMA: Machine Learning

- **Avoidance of pro-cyclicality**
  - ML may improve predictive power and reactivity of a risk model, but
  - Regulatory texts strongly restrict weighting of the recent returns in VAR
  - Regulators are strongly concerned about pro-cyclicality
  - If ML is primed to devise the best possible predictor of 1-day risk, will it introduce weighting?
    - Adding intraday information may in effect create such weighting via back door
- ***Illustration.*** *A few questions to consider for ML VAR*
  - Start with pre-ML classic. What we already know and discussed
    - Proxy spreads: intersection method (also called bucket method) vs. cross-section method, the latter one proposed in (Chourdakis, et al., 2013)
    - CDS: use of single name time series directly may not provide the best estimate of the spread's future evolution
  - Expand to total population. ML could be viewed as all across all non-linear regression
  - No longer missing returns (main HVAR shortcoming), plus best predictor possible
  - Definition of risk factors: let ML decide on regime or impose regime, e.g. return type (Deguillaume, et al., 2013). Simple, at least in principle?...
  - Recall regulatory discussion of proxy spreads and use of proxies in Basel 3 and 4! And we thought that was complicated…

New challenges to Market Risk IMA: Machine Learning

- Illustration continued. Look at one detail: regime/return type. This single question need full size talk to address:
  - Quant Minds, May 2018: *Rates regimes for risk modelling for VAR, ES and PFE: developed and emerging markets; interest rates and inflation*, Cheron, Chorniy, Kotecha, Lichtner, Triki [speakers: Kotecha, Chorniy]
  - For VAR it describes returns regime (or gives definition of returns) and improve predictive power, another way to look at it is a local elasticity model with potential impact on EE/PFE and CVA modelling
    - Multiple angles, different solutions possible: covering negative rates; multiple ways to derive; local vs. macroeconomic view; individual currencies, tenors, markets (G10 and emerging markets); extending to inflation...



- Prediction for Basel 5: regulators will react to ML and will be conservative
- Main deployment as risk predictor – buy side? Banks: first use as challenger model?

Potential Basel 5 topics or what to expect in 2027:

Looking from 2017 into 2027 we can expect guidance

- “Multi-mode” IMM/IMA

CCR:

- In IMM related topics in CCR
  - Modelling of IM
  - Payment risk (“spikes”)
  - Modelling of extreme events and/or scenarios
- Modelling of extreme events and/or scenarios
  - Some extreme events treatment may be prescribed
  - Back testing limitations may be recognised

Market risk; model monitoring and validation:

- Guidance on use of Machine Learning
  - When applicable
  - Minimal requirements: cyclicality, stability, transparency etc. ...

References

Further references from BNP Paribas in the public domain:

1. Moran L, Wilkens S, 2016. *Capturing Initial Margin in Counterparty Risk Calculations*. Journal of Risk Management in Financial Institutions, Vol. 10, 2017, pp. 118-129.
2. Chorniy V, Greenberg A, 2015. *Review of Equity-Credit Dependence Studies: Towards Building a Practical Equity-Credit Model for Counterparty Risk*. Available at http://ssrn.com/abstract=2708143.
3. Wilkens S, Brunac J-B, Chorniy V, 2013. *IRC and CRM: Modelling Framework for the 'Basel 2.5' Risk Measures.* European Financial Management Vol. 19, Issue 4, pp. 801-829.
4. Wilkens S, Predescu M, 2016. *Default Risk Charge (DRC): Modeling Framework for the 'Basel' Risk Measure.* Journal of Risk, Vol. 19, No. 4, 2017, pp. 23-50.
5. Chorniy V, Greenberg A, 2017. *Bayesian Networks and Stochastic Factor Models*, Available at SSRN: https://ssrn.com/abstract=2688324.

Additional references on IM and 'spike' modelling:

6. Andersen L, Pykhtin M, Sokol A, 2016, *Rethinking Margin Period of Risk*, https://ssrn.com/abstract=2719964.
7. Andersen L, Pykhtin M, Sokol A, 2016, *Credit Exposure in the Presence of Initial Margin*, https://ssrn.com/abstract=2806156.

Acknowledgments

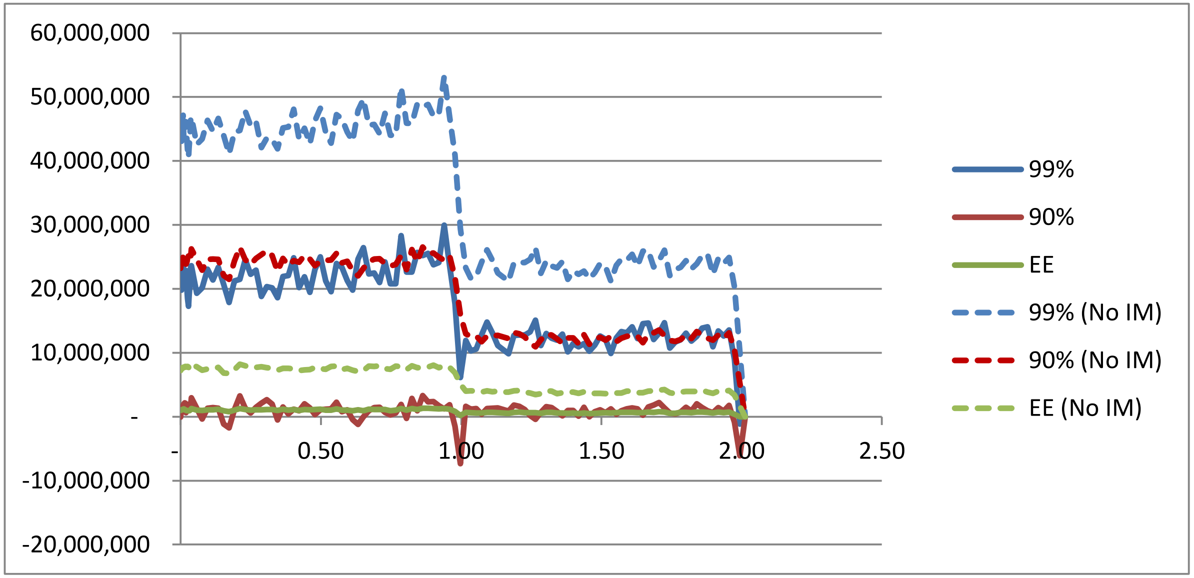
- The contributions of Lee Moran and Sascha Wilkens to these slides are gratefully acknowledged.

Appendix: IM models. Static

- Static model proposal*
  - Allocate day zero to IM to each trade, i, pro-rata using standalone day zero VaR.

$$IM^i(u,t) = IM(0)\frac{VaR^i(0)}{\sum_i VaR^i(0)} \qquad \text{for all } u,t$$

  - For the purposes of illustration we assume IM is calculated on 90% 10-day VaR and look at client-side portfolios (where we hold the IM.)
  - Example portfolio – 2 long vanilla calls 1Y and 2Y maturity:



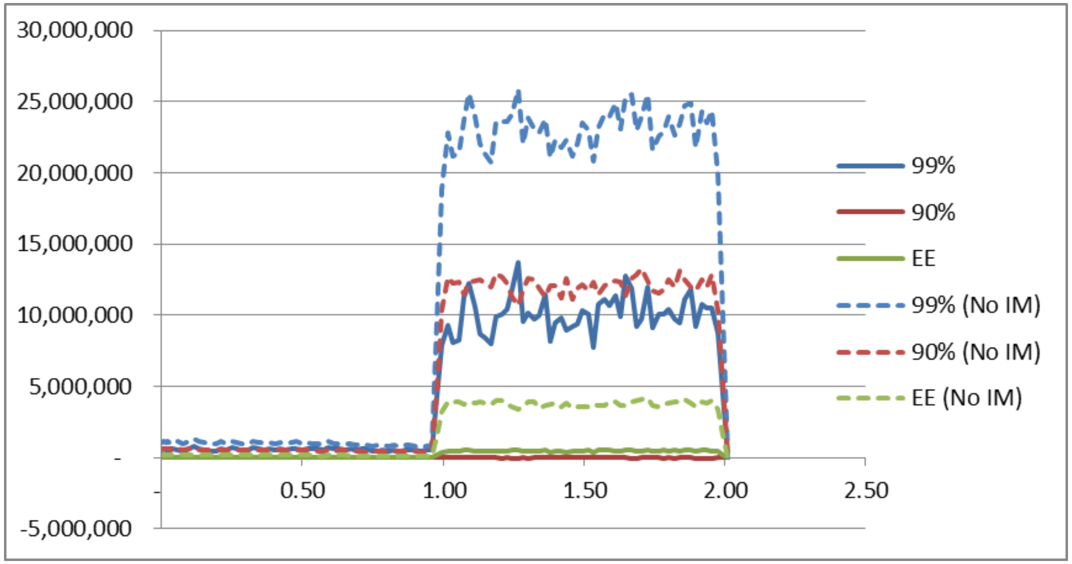
*These IM slides are adopted from presentation by Lee Moran and Peter Dobranszky and follow [1]: Moran L, Wilkens S, 2016.

Appendix: IM models. Dynamic

- Dynamic model proposal
  - Day zero portfolio IM scaled at each future time, t, by VaR at t

$$IM(u,t) = IM(0)\frac{VaR(t)}{VaR(0)}$$

  - Second example portfolio – 2 vanilla calls 1Y (short) and 2Y (long) maturity:

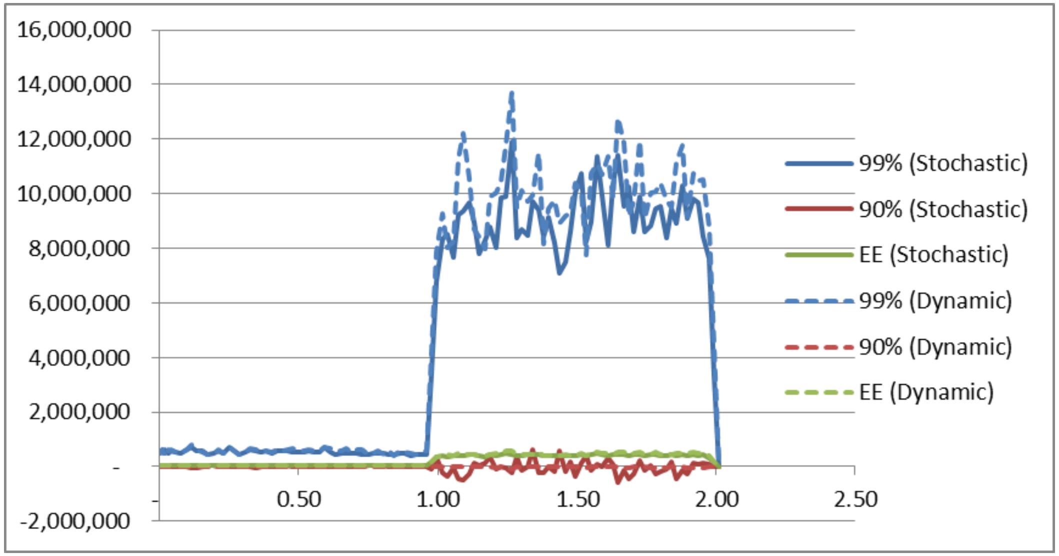


- Dynamic model copes with trade roll-off and portfolio offset effects generally

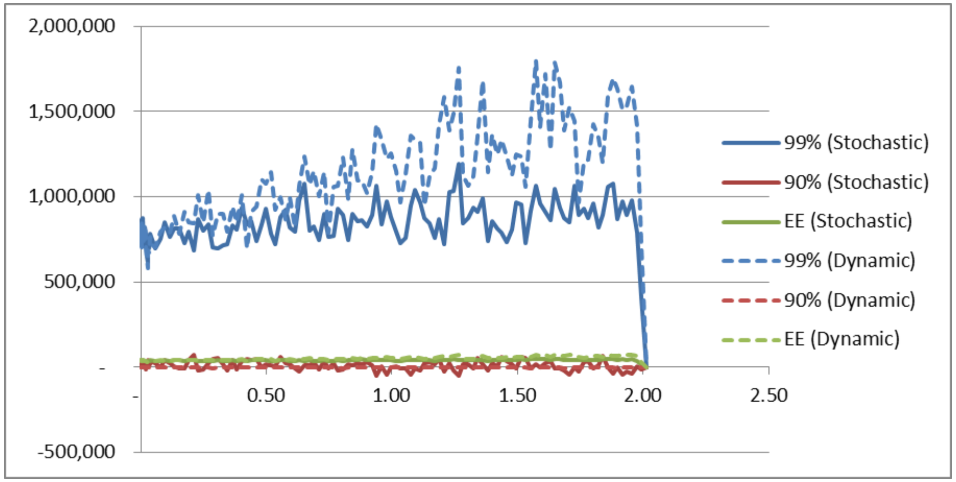
- Stochastic model proposal
  - Day zero portfolio IM is scaled by an estimate of the VaR at each future date within each path[1].

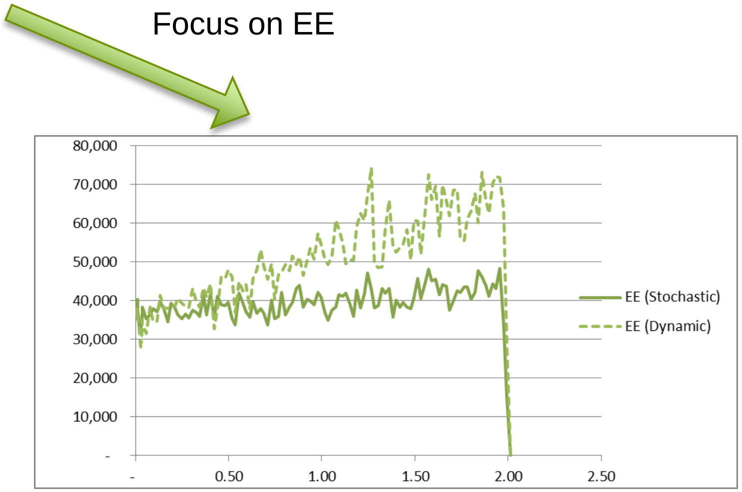
$$IM(u,t) = IM(0)\frac{VaR_q(u,t)}{VaR_q(0)}$$

  - On the second portfolio the stochastic model performance is similar to the dynamic



- For illustrative purposes we take a third portfolio, a high volatility, out of the money call where the VaR is more strongly scenario dependent[2].





- Can give a [relatively] material reduction in the EE. Extreme scenarios could be even stronger affected

[1] How we approximate that without resorting to a brute force simulation approach is the clever part, see [1]

[2] Volatility is not stochastic in these simulations but if it were then the results would be further emphasised

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